SSI-202 P

Catalog Number 276-1303

ARCHER®

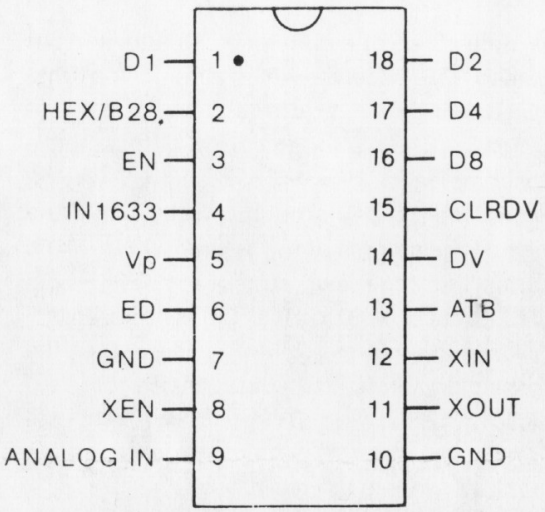
TECHNICAL DATA

AN EXCLUSIVE RADIO SHACK SERVICE TO THE EXPERIMENTER

5V LOW POWER DTMF RECEIVER

FEATURES

- Central Office Quality
- NO front-end band-splitting filters required
- Single, low tolerance, 5-volt supply
- Detects either 12 or 16 standard DTMF digits
- Uses inexpensive 3.579545-MHz crystal (272-1310)
- Excellent speech immunity
- Output in either 4-bit hexadecimal code or binary coded 2 of 8
- 18-pin DIP package for high system density
- Synchronous or handshake interface
- Three-state outputs



DESCRIPTION

The 276-1303 DTMF Receiver is a complete Dual Tone Multiple Frequency (DTMF) receiver detecting a selectable group of 12 or 16 standard digits. No front-end pre-filtering is needed. The only externally required components are an inexpensive 3.58Mhz television "colorburst" crystal (272-1310) and a bias resister. Extremely high system density is made possible by using the clock output of a crystal connected 276-1303 DTMF Receiver to drive the time bases of additional receivers. The 276-1303 is a monolithic integrated circuit fabricated with low-power, complementary symmetry MOS (CMOS) processing. It requires only a single low tolerance voltage supply and is packaged in a standard 18-pin plastic DIP.

The 276-1303 employs state-of-the-art circuit technology to combine digital and analog functions on the same CMOS chip using a standard digital semiconductor process. The analog input is pre-processed by 60-Hz reject and band splitting filters and then hard-limited to provide AGC. Eight bandpass filters detect the individual tones. The digital post-processor times the tone durations and provides the correctly coded digital outputs. Outputs interface directly to standard CMOS circuitry, and are three-state enabled to facilitate bus-oriented architectures

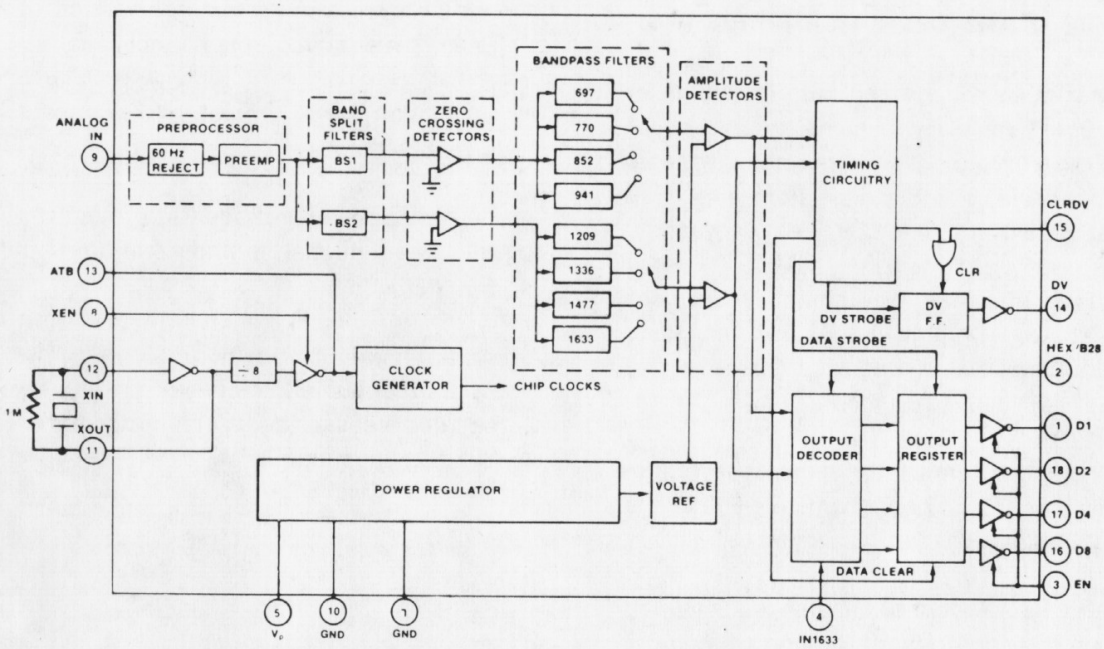


Figure 1. DTMF Receiver Block Diagram

ABSOLUTE MAXIMUM RATINGS*

DC Supply Voltage V_p . . . . . + 7 Volts
Operating Temperature . . 0°C to 70° Ambient
Storage Temperature . . . . . -65°C to 150°C
Power Dissipation (25°C) 65mW
(Derate above T_A= 25°C @ 6.25mW/°C)
Input Voltage . . . . . (V_p + .5V) to -.5V
(All inputs except ANALOG IN)
ANALOG IN Voltage . . (V_p + .5V) to (V_p - 10V)
DC Current into any Input . . . . . + /-1.0mA
Lead Temperature . . . . . 300°C
(soldering, 10 sec.)

*Operation above absolute maximum ratings may damage the device.

NOTE: All unused inputs must be connected to V_p or GND, as appropriate.

ELECTRICAL CHARACTERISTICS (0°C ≤ T_A ≤ 70°C, V_p = 5V ± 10%)

Parameter	Conditions	Min	Typ	Max	Units
Frequency Detect Bandwidth		±(1.5 + 2 Hz)	±2.3	± 3.5	% of f_O
Amplitude for Detection	each tone	-32		-2	dBm referenced to 600Ω
Minimum Acceptable Twist	twist = high tone / low tone	-10		+10	dB
60-Hz Tolerance				0.8	Vrms
Dial Tone Tolerance	"precise" dial tone			0dB	dB referenced to lower amplitude tone
Talk Off	MITEL tape #CM 7290		2		hits
Digital Outputs (except XOUT)	"0" level, 400 μA load "1" level, 200 μA load	0 V_p - 0.5		0.5 V_p	Volts Volts
Digital Inputs	"0" level "1" level	0 0.7V_p		0.3V_p V_p	Volts Volts
Power Supply Noise	wide band			10	mV p-p
Supply Current	T_A = 25°C		10	16	mA
Noise Tolerance	MITEL tape #CM 7290			-12	dB referenced to lowest amplitude tone
Input Impedence	$V_p \geq V_{in} \geq V_p$-10	100KΩ//15pF			

PIN FUNCTIONS

ANALOG IN (Pin 9)

This pin accepts the analog input. It is internally biased so that the input may be DC coupled as long as it does not exceed the positive supply. The 276-1303 is designed to accept sinusoidal input wave forms but will operate satisfactorily with any input that has the correct fundamental frequency with harmonics greater than 20 dB below the fundamental.

CRYSTAL OSCILLATOR (Pins 8, 11, 12 and 13)

The 276-1303 DTMF Receiver contains an onboard inverter with sufficient gain to provide oscillation when connected to a low-cost television "color-burst" crystal (272-1310). The crystal oscillator is enabled by tying XEN (Pin 8) high. The crystal is connected between XIN and XOUT. A 1 MOhm 10% resistor is also connected between these pins. In this mode ATB (Pin 13) is a clock frequency output. Other DTMF Receivers may use the same frequency reference by tying their ATB pins to the ATB of a crystal connected device. XIN and XEN of the auxiliary devices must then be tied high and low respectively. Ten devices may run off of a single crystal-connected 276-1303 as shown below.

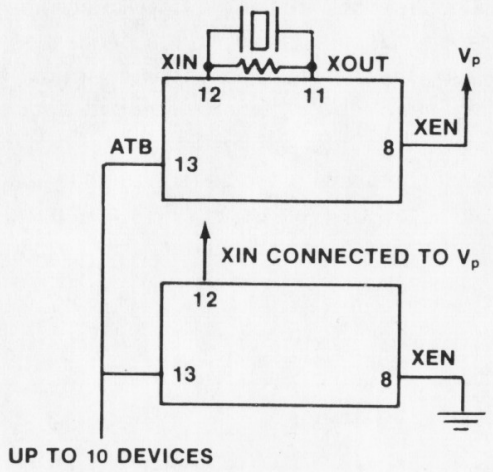


Figure 2.

HEX/B28 (Pin 2)

This pin selects the format of the digital output code. When HEX/B28 is tied high, the output is hexadecimal. When tied low, the output is binary coded 2 of 8. The table below describes the two output formats.

	Hexadecimal				Binary Coded 2 of 8			
Digit	D8	D4	D2	D1	D8	D4	D2	D1
1	0	0	0	1	0	0	0	0
2	0	0	1	0	0	0	0	1
3	0	0	1	1	0	0	1	0
4	0	1	0	0	0	1	0	0
5	0	1	0	1	0	1	0	1
6	0	1	1	0	0	1	1	0
7	0	1	1	1	1	0	0	0
8	1	0	0	0	1	0	0	1
9	1	0	0	1	1	0	1	0
0	1	0	1	0	1	1	0	1
*	1	0	1	1	1	1	0	0
#	1	1	0	0	1	1	1	0
A	1	1	0	1	0	0	1	1
B	1	1	1	0	0	1	1	1
C	1	1	1	1	1	0	1	1
D	0	0	0	0	1	1	1	1

1N1633 (Pin 4)

When tied high, this pin inhibits detection of tone pairs containing the 1633-Hz component. For detection of all 16 standard digits, 1N1633 must be tied low.

OUTPUTS D1, D2, D4, D8 and EN (Pins 1, 18, 17, 16 and 3)

Outputs D1, D2, D4, and D8 are CMOS push-pull when enabled (EN high) and open circuited (high-impedence) when disabled by pulling EN low. These digital outputs provide the code corresponding to the detected digit in the format programmed by the HEX/B28 pin. The digital outputs become valid after a tone pair has been detected and they are then cleared when a valid pause is timed.

DV and CLRDV (Pins 14 and 15)

DV signals a detection by going high after a valid tone pair is sensed and decoded at the output pins of D1, D2, D4 and D8. DV remains high until a valid pause occurs or the CLRDV is raised high, whichever occurs first.

N/C PIN (Pin 6)

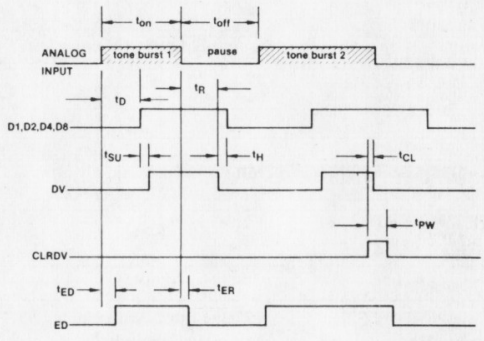
This pin has no internal connection and may be left floating.

DTMF DIALING MATRIX

	Col 0	Col 1	Col 2	Col 3
Row 0	1	2	3	A
Row 1	4	5	6	B
Row 2	7	8	9	C
Row 3	*	0	#	D

Note: Column 3 is for special applications and is not normally used in telephone dialing.

DTMF RECEIVER TIMING



PARAMETER	SYMBOL	MIN.	TYP.	MAX.	UNITS
TONE TIME: for detection	t_{ON}	40	—	—	mS
for rejection	t_{ON}	—	—	20	mS
PAUSE TIME: for detection	t_{OFF}	40	—	—	mS
for rejection	t_{OFF}	—	—	20	mS
DETECT TIME	t_D	25	—	46	mS
RELEASE TIME	t_R	35	—	50	mS
DATA SETUP TIME	t_{SU}	7	—	—	µS
DATA HOLD TIME	t_H	4.2	—	5.0	mS
DV CLEAR TIME	t_{CL}	—	160	250	nS
CLRDV pulse width	t_{PW}	200	—	—	nS
OUTPUT ENABLE TIME C_L = 50pF R_L = 1KΩ	—	—	200	300	nS
OUTPUT DISABLE TIME C_L = 35pF R_L = 500Ω	—	—	150	200	nS
OUTPUT RISE TIME C_L = 50pF	—	—	200	300	nS
OUTPUT FALL TIME C_L = 50pF	—	—	160	250	nS

Application Guide For The 276-1303 Dual-Tone Multi-Frequency (DTMF) Receiver

The 276-1303 Integrated DTMF Receiver is a complete Touch-Tone detection system. It can operate in a stand-alone mode for the majority of telecommunications applications, thereby providing the most economical implementation of DTMF signaling systems possible. The IC combines precision active filters and analog circuits with digital control logic on a monolithic CMOS integrated circuit. The use of the DTMF Receiver is straightforward and the external component requirements are minimal.

This application guide describes device operation, performance, system requirements, and typical application circuits for the DTMF Receiver IC.

How the DTMF Circuit Works

General Description of Operation

The task of a DTMF Receiver is to detect the presence of a valid tone pair on a telephone line or other transmission medium.

The presence of a valid tone pair indicates a single dialed digit; to generate a valid digit sequence, each tone pair must be separated by a valid pause.

The following table gives the established Bell system standards for a valid tone pair and a valid pause:

One Low-Group Tone -and- One High-Group Tone	697 or 770 or 852 or 941 Hz 1209 or 1336 or 1477 or 1633 Hz
Frequency Tolerance	f_o (1.5% + 2 Hz)
Amplitude Range	-24 dBm < A < +6dBm @ 600 Ohm (Dynamic Range 30 dB)
Relative Amplitude (Twist)	High-Group Tone -8dB < Low-Group Tone < +4 dB
Duration	40ms or longer
Inter-tonal Pauses	40ms or longer

The 276-1303 DTMF Receiver meets or exceeds these standards.

Figure 1 shows the DTMF Receiver Block Diagram. In general terms, the detection scheme is as follows: The input signal is prefiltered and then split into two bands, each of which contains only one DTMF tone group. The output of each band-split filter is amplified and limited by a zero-crossing detector. The limited signals, in the form of square waves, are passed through tone frequency band pass filters. Digital logic is then used to provide detector sampling and determine detection validity, to present the digital output data in the correct format, and to provide device timing and control.

Description of Operation

Noise and Speech Immunity

The two largest problems confronting a DTMF Receiver are:

1) Distinguishing between valid tone pairs (or pauses) and other stray signals (or speech) that contain valid tone pair frequencies.

2) Detecting valid tone pairs in the presence of noise, which is typically found in the telephone (or other transmission medium) environment.

The 276-1303 DTMF Receiver uses several techniques to distinguish between valid tone pairs and other stray signals. Briefly, the techniques are:

1) Pre-filtering of audio signal. Removes supply noise and dial-tone from the input audio signal and emphasizes the voice frequency domain.

2) Zero-cross detection. Limits the acceptable level of noise during detection of a tone pair. Important for speech rejection.

3) Valid tone pair/pause sampling. Samples the detection filters and checks for consistency before determining that a received tone pair or pause is valid.

How To Use the DTMF Receiver

Precautions

Although static protection devices are provided on the high impedence inputs, normal handling precautions observed for CMOS devices should be used.

A destructive high current latch-up mode will occur if pin voltages are not constrained to the range between -.5 Volts and V_p + .5 Volts (except Analog Input as described below). In applications where voltage spikes may occur, protection must be provided to ensure that the maximum voltage ratings are not exceeded. This may require the use of clamping diodes on the Analog Input to protect against ringer voltage, for example, or on the power supply to protect against supply spikes.

Power Supply

Excessive power supply noise should be avoided. Since the digital circuitry of the device possesses the high noise immunity characteristics of CMOS logic, limited power supply noise is required only for the analog section. The analog circuitry of the device requires lower power supply noise levels, as specified in the Electrical Characteristics. Power supply noise effects will be slightly less if the analog input is referenced to V_p. This is normally accomplished by connecting V_p to ground and utilizing a negative power supply. The effects of excessive power supply noise will cause decreased tone amplitude sensitivity and less tone detection frequency bandwidth.

Digital Inputs

The digital inputs are directly compatible with standard CMOS logic devices powered by V_p. The input logic levels should swing within 30% of V_p to insure detection. Any unused input must be tied to V_p or Ground.

Analog Input

The Analog Input is the signal input pin for the device, and is specially biased to facilitate its connection to external circuitry, as shown in Figure 3. The signal level at the Analog Input pin must not exceed or fall more than a few volts below the positive supply as stated in the Electrical Specifications. If this condition cannot be guaranteed by the external circuitry, the signal must be AC coupled into the chip with a .01 uF 20% capacitor.

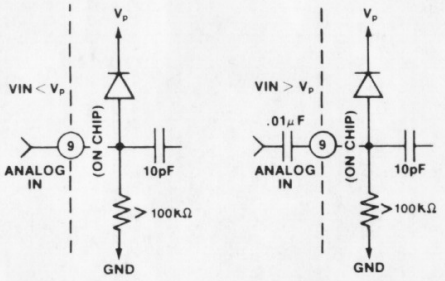
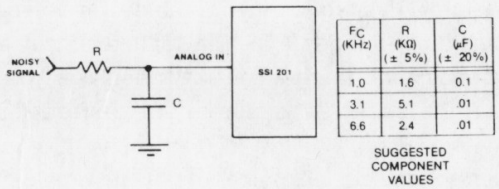


Figure 3. Direct and AC coupled configurations

A 1KHz cut-off frequency filter can be used on "normal" phone lines for special applications. When a phone line is particularly noisy, tone pair detection may be unreliable. A 1KHz low pass filter will remove much of the noise energy but maintain the tone groups; however, a decreased speech immunity will result. This usage should only be considered for applications where speech immunity is not important, such as control paths that carry no speech.

Some DTMF Generators output distorted tones which the 276-1303 DTMF Receiver may not detect reliably (inexpensive extension telephones are an example). Most of the interfering harmonics of these tones may be removed by the use of a 3 KHz low-pass filter as in Figure 4. Some speech immunity degradation will result, but not as bad as using the 1KHz filter mentioned above.



F_C (KHz)	R (KΩ) (± 5%)	C (μF) (± 20%)
1.0	1.6	0.1
3.1	5.1	.01
6.6	2.4	.01

SUGGESTED COMPONENT VALUES

Figure 4. Filter for use in noisy environments

Analog Input Noise

This DTMF Receiver will tolerate wide-band input noise of up to 12dB below the lowest amplitude tone fundamental during detection of a valid tone pair. Any single interference frequency (including tone harmonics) between 1 KHz and 6 KHz should be at least 20 dB below the lowest amplitude tone fundamental. Adherence to these conditions will ensure reliable detection and full tone detection frequency bandwidth. Because of the internal band limiting, noise with frequencies above 8KHz can remain unfiltered. However, noise near the 56KHz internal switched-capacitor-filter sampling frequency will be aliased (folded back) into the audio spectrum; noise above 28KHz therefore should be low-pass filtered with a circuit as shown in Figure 4 using a cut-off frequency (F_C) of 6.6KHz.

Telephone Line Interface

In applications that use a DTMF Receiver to decode DTMF signals from a phone line, a DAA (Direct Access Arrangement) must be implemented. Equipment intended for connection to the public telephone network must comply with and be registered in accordance to FCC Part 68. For PBX applications refer to EIA Standard RS-464.

Some of the basic guidelines are:

1) Maximum voltage and current ratings of the DTMF Receiver must not be exceeded; this calls for protection from ringing voltage, if applicable, which ranges from 80 to 120 Volts RMS over a 20 to 80Hz frequency range.

2) The interface equipment must not breakdown with high-voltage transient tests (including a 2500 Volt peak surge) as defined in the applicable document.

3) Phone line termination must be less than 200 Ohms DC and approximately 600 Ohms AC (200-3200 Hz).

4) Termination must be capable of sustaining phone line loop current (off-hook condition) which is typically 18 to 120 mA DC.

5) The phone line termination must be electrically balanced in respect to ground.

6) Public phone line termination equipment must be registered in accordance with FCC Part 68 or connected through registered-protection circuitry. Registration typically takes about six months.

Figure 5 shows a simplified phone line interface using a 600 Ohm 1:1 line transformer. Transformers specifically designed for phone line coupling are available from many transformer manufacturers.

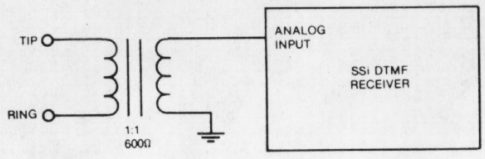


Figure 5. Simplified Phone Line Interface

Figure 6 shows a more featured version of Figure 5. These added options include:

1) A 150 Volt surge protector to eliminate high voltage spikes.

2) Back-to-back Zener diodes to protect the DTMF (and optional multiplexer Op-Amp) from ringer voltage..

3) Audio multiplexer which allows either voice or other audio to be placed on the line (a recorded message, for example) and not interfere with incoming DTMF tone detection.

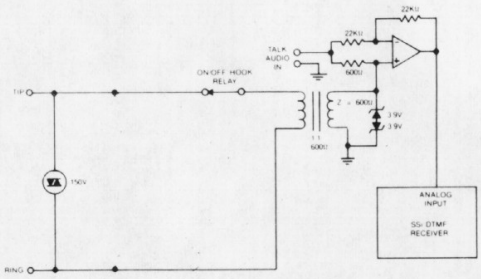


Figure 6. Full Featured Phone Line Interface

An integrated voice circuit may also be implemented for line coupling, however this approach is typically more expensive than using a transformer as shown above.

Outputs

The digital outputs of the DTMF Receiver (Except XOUT) swing between V_p and GND and are fully compatible with standard CMOS logic devices powered from V_p and GND. The device will also interface directly to LSTTL.

Data Outputs D8, D4, D2 and D1 are three state enabled to facilitate interface to a three-state bus. Figure 7 shows the equivalent circuit for the data outputs in the high impedence state. Care must be taken to prevent either substrate in Figure 7 from becoming forward biased or damage may result.

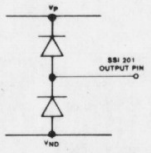


Figure 7. Equivalent Circuit of DTMF Receiver Data Output in High Impedance State.

Timing

Within 40 ms of a valid tone pair appearing at the DTMF Receiver Analog Input, the Data Outputs will become valid. Seven-microseconds after the data outputs have become valid DV will be raised. DV will remain high and the outputs valid while the valid tone pair remains present. Within 40 ms after the tone pair stops, the DTMF will recognize a valid pause. DV is lowered approximately 45 ms following the end of the tone pair, and the data outputs all set to zero 4.56 ms following DV going low. DV will strobe at least for the same duration as the received tone pair.

System Interface

Provision has been made on the 276-1303 for handshake interface with an outside monitoring system. In this mode, the DV strobe is polled by the monitoring system at least once every 40 ms to determine whether a new valid tone pair has been detected. If DV is high, the coded data is stored in the monitoring system and then CLRDV is pulsed high. With some systems operating in the handshake mode, it may be desirable to know when a valid pause has occurred. Ordinarily this would be indicated by the falling edge of DV. However, in the handshake mode, DV is cleared by the monitoring system each time a new valid tone pair is detected and, therefore, cannot be used to determine when a valid pause is detected. The detection of a valid pause in this case may be observed by detecting the clearing of the Data Outputs. Since, in hexidecimal format (the mode normally used with a handshake interface), the all zero state represents a commonly unused tone pair (D), the detection of a valid pause may be detected by connecting a four-input NOR gate to the device outputs and sensing the all zero state.

Time Base

The DTMF Receiver contains an on-chip oscillator for a 3.5795 MHz parallel resonant quartz crystal or ceramic resonator. The crystal (or resonator) is placed between XIN and XOUT in parallel with a 1 MOhm resistor, while XEN is tied high. Since the switched-capacitor-filter time base is derived from the oscillator, the tone detect band frequency tolerance is proportional to the time base tolerance. The 276-1303 frequency response and timing is guaranteed with a time base accuracy of at least .01%. To obtain this accuracy, a quartz crystal is recommended. In less critical applications a suitable ceramic resonator may be implemented.

The use of a ceramic resonator requires the addition of two 30 pF 10% capacitors; one between XIN and Ground and the other between XOUT and Ground. Extra caution should be used to avoid stray capacitance on the resonant circuit when using a ceramic resonator instead of a quartz crystal.

When the oscillator is connected as above and XEN is tied high, the ATB (Alternate Time Base) pin delivers a square wave output at one-eighth the oscillator frequency (447.443 KHz nominal). The ATB pin can be converted to a time base input by tying XEN low; ATB can then be externally driven from another device such as the ATB output of another DTMF Receiver. No crystal is required for the ATB input device; XIN must be tied high if unused. Several DTMF receivers can be driven with a single crystal.

XOUT is designed to drive a resonant circuit only and is not intended to drive additional devices. If a 3.58 HHz clock is needed for more than one device and it is desirable to use only one resonant device, and outside inverter should be used for the time base, buffered by a second inverter or buffer. The buffer output would then drive XIN of the DTMF Receiver as well as the other device(s); XOUT must be left floating and XEN tied high.

Dial Tone Rejection

The 276-1303 DTMF Receiver incorporates enough dial tone rejection circuitry to provide dial tone tolerance of up to 0 dB. Dial tone tolerance is defined as the total power of precise dial tone (350Hz and 440Hz at equal amplitudes) relative to the lowest amplitude tone in a valid tone pair. The filter of Figure 8 may be used for further dial tone rejection. This filter exhibits an elliptic highpass response that provides a minimum of 18 dB rejection at 350Hz and 24 dB rejection at 440 Hz so long as the component tolerances indicated are observed. The DTMF on-chip filter rejects 350 Hz at least 6 dB more than 440 Hz. Therefore, employing the filter of Figure 8 yields a dial tone tolerance of + 24 dB.

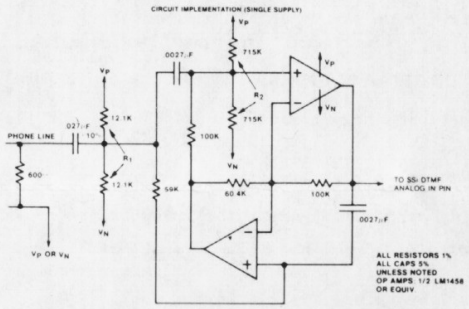


Figure 8. Dial Tone Reject Filter

Printed Circuit Board Implementation

The 276-1303 DTMF Receiver is analog in nature and should be treated as such; circuit noise should be kept to a minimum. To be certain of this, all input and output lines should be kept away from noise sources (high frequency data or clock lines); this is especially true for the Analog Input. Noise in the ground or power supply lines can be avoided by running separate traces to supportive logic circuits or by running thicker (lower resistance) busses. Capacitance power supply bypassing should be performed at the device. Refer to the Power Supply section above.

APPLICATIONS

16-Channel Remote Control

DTMF Signaling provides a simple, reliable means of transmitting information over a 2-wire twisted pair. The complete schematic of a 16-channel remote control is shown in Figure 9. When one of the key pad buttons is depressed, a tone pair is sent over the transmission medium to the DTMF Receiver. The SK4514B raises one of its 16 outputs in response to the 4-bit output code from the DTMF. The output at the 4514 will remain high until the next button is depressed.

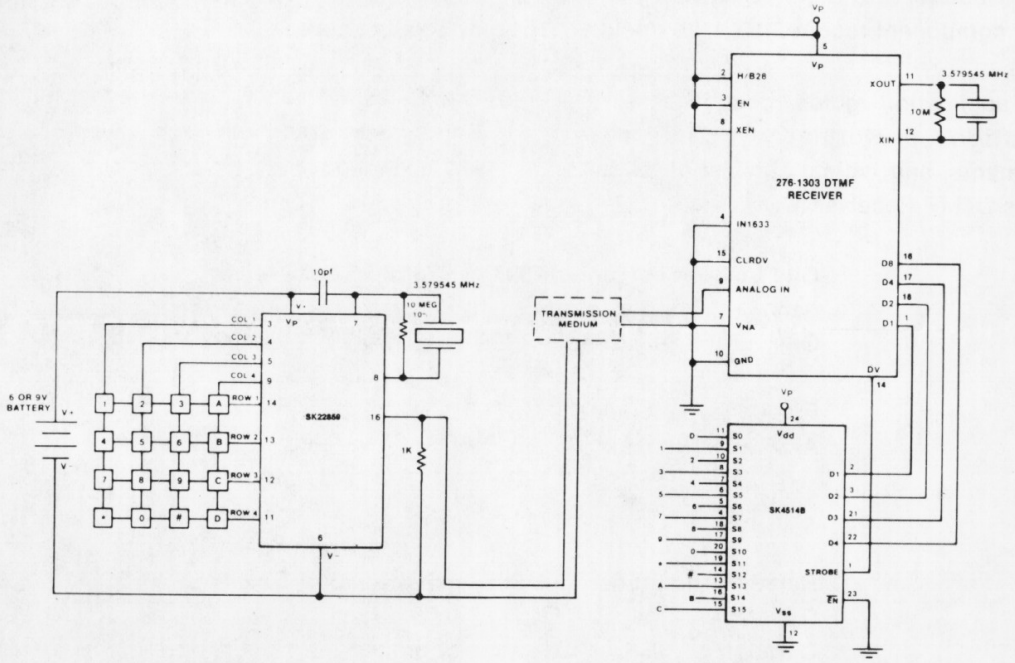


Figure 9. 16 Channel Remote Control

2-of-8 Output Decode

The circuit shown in Figure 10 can be used to convert the binary coded 2-of-8 to the actual 2 of 8 code (or 2 of 7 if detection of 1633 Hz tone is inhibited). The output data will be valid while DV is high. If it is desired to force the eight outputs to zero when a valid tone is not present, DV should be inverted and connected to both E-NOT inputs of the SK4555B.

Note: All semiconductor components shown can be ordered through your local Radio Shack. Refer to the "SK" series number when ordering.

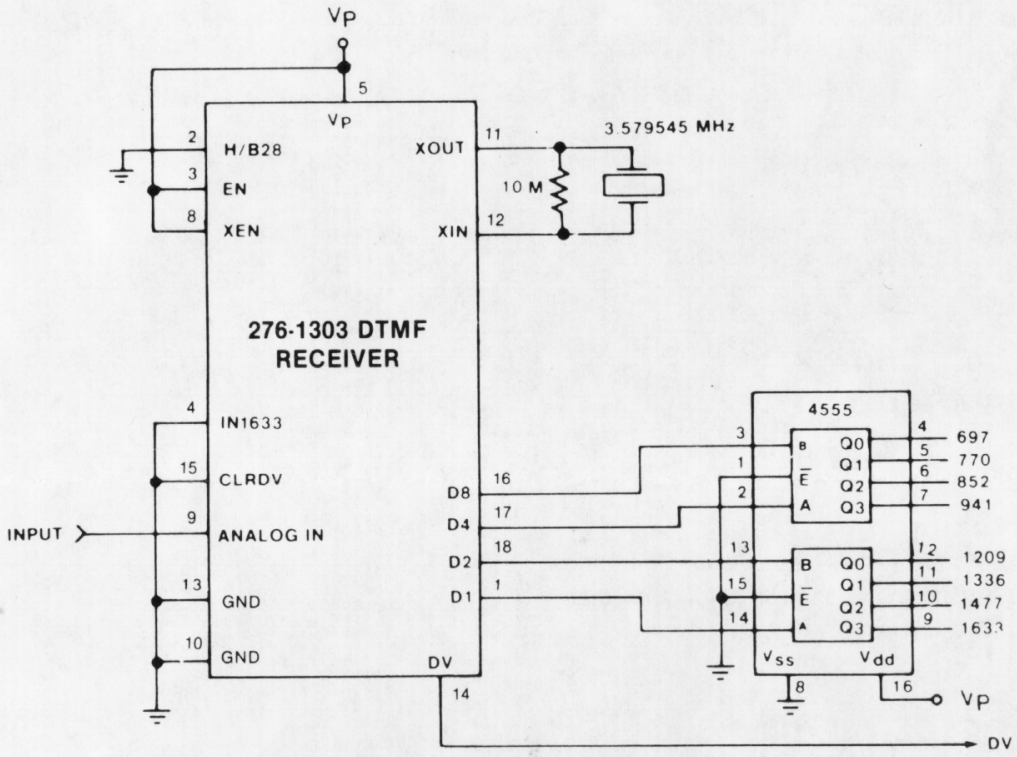


Figure 10. Touch Tone to 2-of-8 Ouput Converter

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CANADA: BARRIE, ONTARIO L4M 4W5

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